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Battlefield extremity injuries in Operation Iraqi Freedom

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ABSTRACT

Objective: Extremity injuries account for the majority of wounds incurred during US armed conflicts. Information regarding the severity and short-term outcomes of patients with extremity wounds, however, is limited. The aim of the present study was to describe patients with battlefield extremity injuries in Operation Iraqi Freedom (OIF) and to compare characteristics of extremity injury patients with other combat wounded.

Patients and methods: Data were obtained from the United States Navy-Marine Corps Combat Trauma Registry (CTR) for patients who received treatment for combat wounds at Navy-Marine Corps facilities in Iraq between September 2004 and February 2005. Battlefield extremity injuries were classified according to type, location, and severity; patient demographic, injury-specific, and short-term outcome data were analysed. Upper and lower extremity injuries were also compared.

Results: A total of 935 combat wounded patients were identified; 665 (71%) sustained extremity injury. Overall, multiple wounding was common (an average of 3 wounds per patient), though more prevalent amongst patients with extremity injury than those with other injury (75% vs. 56%, $P < .001$). Amongst the 665 extremity injury patients, 261 (39%) sustained injury to the upper extremities, 223 (34%) to the lower extremities, and 181 (27%) to both the upper and lower extremities. Though the total number of *patients* with upper extremity injury was higher than lower extremity injury, the total number of extremity *wounds* ($n = 1654$) was evenly distributed amongst the upper and lower extremities (827 and 827 wounds, respectively). Further, lower extremity injuries were more likely than the upper extremity injuries to be coded as serious to fatal (AIS > 2, $P < .001$).

Conclusions: Extremity injuries continue to account for the majority of combat wounds. Compared with other conflicts, OIF has seen increased prevalence of patients with upper extremity injuries. Wounds to the lower extremities, however, are more serious. Further research on the risks and outcomes associated with extremity injury is necessary to enhance the planning and delivery of combat casualty medical care.

Introduction

Battlefield extremity injuries account for the majority of combat wounds sustained by United States armed forces during military conflicts of the twentieth century.[10,12,13,18,19] Extremity wounds, however, account for a relatively small proportion of battlefield and hospital deaths compared with head, chest, and abdominal wounds.[5,18,19] Overall, more than 65% of the wounded survivors from World War II and the Korean War sustained extremity injuries.[18,19] Despite the changing nature of warfare, the prevalence of extremity injuries during Operation Enduring Freedom and Operation Iraqi Freedom (OIF) is comparable to previous US military conflicts.[11,15,16,22]

The emerging and widespread use of improvised explosive devices (IEDs) has resulted in new injury patterns amongst combat casualties during OIF compared with previous conflicts.[9,20] In combat, lower extremity injuries (LEIs) are generally more common than upper extremity injuries (UEIs: 37–42% vs. 27–29%).[18,19] Recent studies from OIF, however, demonstrate equivalent and, in some cases, higher proportion of UEIs to LEIs.[9,16,17,22] The difference in severity of upper and lower extremity injuries has not been examined.

The objectives of this descriptive study were to characterise the prevalence, types, and severities of battlefield extremity injuries amongst US service members who received treatment for their injuries at Navy-Marine Corps facilities during OIF, and to compare injury-specific and short-term outcomes of (a) patients with extremity injury versus those with other injuries and (b) patients

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with UEI versus those with LEI. This research was conducted in compliance with all applicable United States federal regulations governing the protection of human subjects in research and was approved by the Institutional Review Board of the Naval Health Research Center, San Diego, CA, United States (Protocol NHRC.2003.0025).

Patients and methods

A retrospective review of clinical encounter data in the United States Navy-Marine Corps Combat Trauma Registry (CTR) was performed. The study population consisted of US service members injured in hostile action who presented to forward-deployed US Navy-Marine Corps medical treatment facilities (MTFs) (i.e., medical units that provide immediate triage and stabilisation of patients before sending them on to a higher level of care within the medical chain of evacuation) during a 6-month period of OIF, September 1, 2004, to February 28, 2005.

The Navy-Marine Corps CTR is a deployment health database that consists of medical treatment information abstracted from hard-copy and electronic records of patients treated for battle and nonbattle injury, disease, psychiatric, and routine sick call at forward-deployed Navy-Marine Corps MTFs in Iraq.[7] The registry is designed to obtain information from multiple levels of care for each patient, starting near the point of injury at Navy-Marine Corps level I (i.e., battalion aid stations) or level II MTFs (i.e., forward resuscitative surgical systems or shock trauma platoons) and continuing through long-term rehabilitative care at military MTFs in the United States.

For the purposes of this study, only medical records from forward-deployed levels of care, and, in the case of evacuated patients, records from combat support hospitals in Iraq and the American hospital in Germany (Landstuhl Regional Medical Center) were analysed. Data were abstracted from these records to obtain the following information for each patient: age; gender; rank; service; mechanism, type, location, and severity of injury; surgical procedures; complications (i.e., any secondary problem that arose following an injury, procedure, or treatment); and disposition.

A diagnosis of extremity injury was indicated by one or more of the extremity *International Classification of Diseases*, 9th Revision, Clinical Modification (ICD-9-CM) codes defined by the Barell injury diagnosis matrix[3] (Table 1). Patients without an extremity injury diagnosis were categorised as "other injury." Patients were also categorised by upper, lower, or both upper and lower extremity injury. Multiple injured casualties with extremity injury were placed in the "extremity injury" category, whereas multiple injured casualties without extremity injury were placed in the "other injury" category.

Injury severity, as indicated by the Abbreviated Injury Scale (AIS) 2005[8] and the Injury Severity Score (ISS),[1,2] and ICD-9-CM codes[6] were retrospectively assessed by clinical research staff at Naval Health Research Center in San Diego, California. The AIS rates the severity of each injury in nine body regions (i.e., head, face, neck, torso, abdomen, spine, upper extremity, lower extremity, and external) and is scored according to the following scale: 0 = no injury, 1 = minor, 2 = moderate, 3 = serious (but not life-threatening injury), 4 = severe (life-threatening injury), 5 = critical (life-threatening injury), and 6 = maximum (fatal injury). The AIS is then used to calculate the ISS (range 0–75), which represents the overall severity of multiple injuries for each patient. Patients with an ISS of 0 were excluded from this analysis; only patients with injuries were included. For the present study, AIS and ISS were categorised as minor to moderate (AIS 1–2; ISS 1–8) and serious to fatal (AIS > 2; ISS > 8).

Disposition was categorised as returned to duty (i.e., wounded in action and fit for full duty, assigned light duty, or sick in quarters), admitted (i.e., wounded in action and admitted for observation to a forward-deployed MTF without further disposition information), evacuated (i.e., wounded in action and medically evacuated to a combat support hospital), and deceased. Patients who were initially evacuated from a level I or II MTF who then subsequently died of their wounds after medical evacuation were categorised as "deceased." Patients with missing disposition information were included as "unknown."

Statistical analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL) and SAS version 9.1 (SAS Institute, Inc., Cary, NC). The prevalence of extremity injury was calculated for the entire cohort. Differences across groups by extremity injury status (extremity injury vs. other) and by extremity injury location (upper, lower, or both) were tested using a *t*-test for independent samples for continuous data (i.e., age), and with chi-square (χ^2) and Fisher's exact tests for categorical data and for the Barell matrix analysis; $\alpha = .05$ was used to determine statistical significance. The Barell matrix was used to describe the nature (or type) of extremity injuries; adjusted standardised residuals were used in the nature-of-injury analysis to identify cells from the crosstabs that had the greatest impact on the χ^2-test statistic (critical values were set at ± 2.0).

Results

A total of 935 combat casualties were identified in the Navy-Marine Corps CTR between September 2004 and February 2005 and sustained a total of 3218 injuries (an average of 3 injuries per patient). Nine patients incurred two separate combat injury events during the study period; each event was counted as one casualty. The mean age was 24 ± 5.2 years (range 18–54 years). All but 8

Table 1
Upper and lower extremity ICD-9-CM codes as defined by the Barell injury diagnosis matrix.

Description	ICD-9-CM Codes
Upper extremity	
Shoulder and upper arm	810–812, 831, 840, 880, 887(.2–.3), 912, 923.0, 927.0, 943(.x3–.x6), 959.2
Forearm and elbow	813, 832, 841, 881(.x0–.x1), 887(.0–.1), 923.1, 927.1, 943(.x1–.x2)
Wrist, hand, and fingers	814–817, 833–834, 842, 881.x2, 882, 883, 885–886, 914–915, 923(.2–.3), 927(.2–.3), 944, 959(.4–.5)
Other and unspecified	818, 884, 887(.4–.7), 903, 913, 923(.8,.9), 927(.8–.9), 943(.x0,x.9), 953.4, 955, 959.3
Lower extremity	
Hip	820, 835, 843, 924.01, 928.01
Upper leg and thigh	821, 897(.2–.3), 924.00, 928.00, 945.x6
Knee	822, 836, 844.0–.3, 924.11, 928.11, 945.x5
Lower leg and ankle	823–824, 837, 845.0, 897(.0–.1), 924(.10,.21), 928(.10,.21), 945(.x3–.x4)
Foot and toes	825–826, 838, 845.1, 892–893, 895–896, 917, 924(.3,.20), 928(.3,.20), 945(.x1–.x2)
Other and unspecified	827, 844(.8,.9), 890–891, 894, 897(.4–.7), 904(.0–.8), 916, 924(.4–.5), 928(.8,.9), 945(.x0,.x9), 959(.6–.7)

Abbreviation: ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical modification.

Table 2
Nature and severity of upper extremity injuries and lower extremity injuries.

Characteristics	Total (n = 1654)	UEIs (n = 827)	LEIs (n = 827)	P value
Nature of injury				<.001[a]
Fracture	316 (19.1)	150 (18.1)	166 (20.1)	
Dislocation	27 (1.6)	16 (1.9)	11 (1.3)	
Sprains and strains	31 (1.9)	6 (0.7)[b]	25 (3.0)[c]	
Open wound	841 (50.8)	400 (48.4)[b]	441 (53.3)[c]	
Amputations	44 (2.7)	22 (2.7)	22 (2.7)	
Blood vessels	87 (5.3)	27 (3.3)[b]	60 (7.3)[c]	
Contusion/superficial	152 (9.2)	67 (8.1)	85 (10.3)	
Crush	2 (0.1)	0 (0.0)	2 (0.2)	
Burns	104 (6.3)	89 (10.8)[c]	15 (1.8)[b]	
Nerves	50 (3.0)	50 (6.0)[c]	0 (0.0)[b]	
AIS > 2[d]	140 (8.5)	32 (3.9)	108 (13.1)	<.001[e]

Abbreviations: AIS, Abbreviated Injury Scale; LEIs, lower extremity injuries; UEIs, upper extremity injuries.
[a] χ^2-test.
[b] Adjusted residual <−2.0.
[c] Adjusted residual >2.0.
[d] Values are missing for 11 injuries because of insufficient information to definitively code.
[e] Fisher's exact test.

patients were male. The majority of patients were junior enlisted (67.4%) and were marines (75.9%).

Overall, 665 (71.1%) combat casualties suffered extremity injury. Of these, 381 (57.3%) had multiple extremity injuries. Altogether, casualties with extremity injury sustained a total of 2640 injuries (an average of 4 injuries per patient), of which 1654 (62.7%) were extremity injuries. As shown in Table 2, upper and lower extremity injuries accounted for equal proportions of the total number of extremity injuries, but a significantly higher proportion of LEIs were coded as serious to fatal injuries (AIS > 2; $P < .001$). Most extremity injuries were open wounds (50.8%), followed by fractures (19.1%), contusions (9.2%), and burns (6.3%). In comparison with the upper extremities, the lower extremities had more open wounds, sprains and strains, and blood vessel injuries. Conversely, the upper extremities sustained more burn and nerve injuries.

The distribution of all anatomic injury locations amongst patients with extremity injury according to ICD-9-CM diagnoses is shown in Fig. 1. Approximately 30% of patients with extremity injury also sustained an injury to the face. Nearly half of all extremity patients sustained a "lower extremity, other and unspecified" injury. It is important to note that the "open wound" category in ICD-9-CM coding is not anatomically specific within the lower extremity category, and the majority of injuries classified as "lower extremity, other and unspecified" were open wounds (75.7%).

Combat casualties with extremity injury did not differ from those with other injuries on the basis of age, gender, military rank, or branch of service. These groups differed, however, with respect to injury-specific and outcome characteristics (Table 3). The overall distributions of injury mechanism were significantly different by extremity injury status ($P < .01$). Only 37.1% of patients with extremity wounds were injured by IEDs, compared with 50.0% of the patients with other anatomical injuries. In contrast, extremity injury patients were more likely than other injury patients to be wounded by gunshot (20.5% vs. 11.9%). Multiple injuries per patient were common (nearly 70% of the study population), but were significantly more prevalent amongst those with extremity injury ($P < .001$). In addition, extremity injury casualties were more seriously injured (ISS > 8; $P < .001$) and were more likely to be evacuated to higher levels of care than other injury casualties (50.8% vs. 23.7%), but fewer died (3.2% vs. 5.9%). Four times as many extremity injury patients as other injury patients underwent operative procedures at forward-deployed

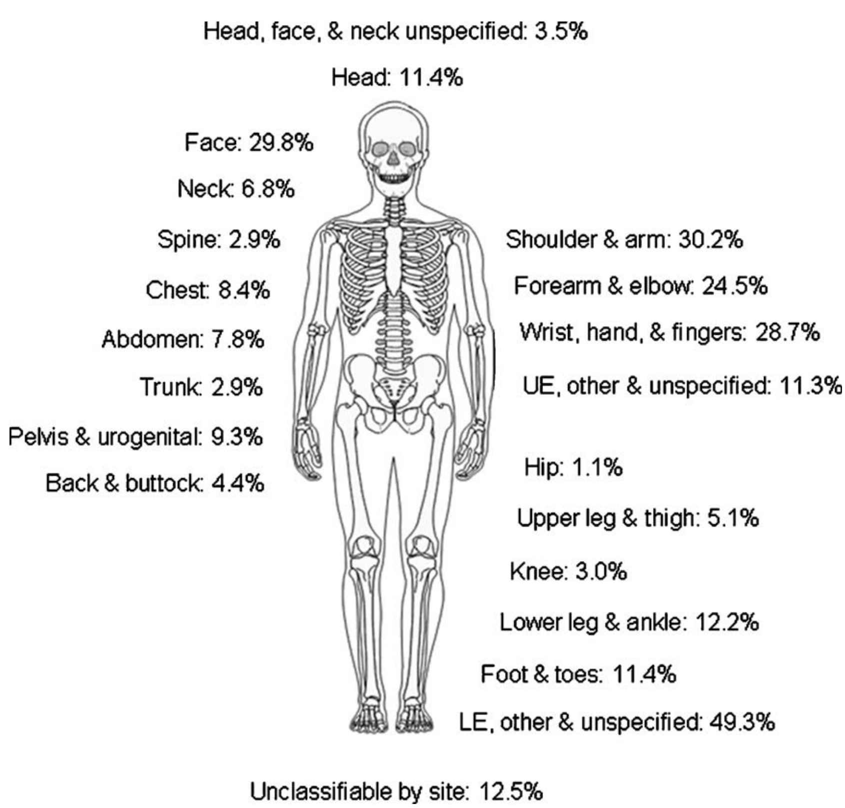

Fig. 1. Distribution of anatomic injury locations amongst extremity injury patients, as defined by the Barell injury diagnosis matrix. UE, upper extremity; LE, lower extremity. Percentages denote the proportion of extremity injury patients with injuries to the stated anatomic location. Because of multiple injury locations per patient, percentages do not total 100.

Table 3
Demographic, injury-specific, and outcome characteristics by injury status amongst combat casualties, Operation Iraqi Freedom, September 2004–February 2005.

Characteristics	Total (n = 935)	Extremity injury (n = 665)	Other injury (n = 270)	P value[a]
Demographic				
Age, mean (SD), years[b]	24.1 (5.2)	23.9 (5.1)	24.4 (5.6)	.21[c]
Male, no. (%)	927 (99.1)	660 (99.2)	267 (98.9)	.70[d]
Rank, no. (%)				.21
E1–E4	630 (67.4)	455 (68.4)	175 (64.8)	
E5–E9	249 (26.6)	167 (25.1)	82 (30.4)	
WO/officer	44 (4.7)	34 (5.1)	10 (3.7)	
Unknown[e]	12 (1.3)	9 (1.4)	3 (1.1)	
Service, no. (%)				.30
Marine Corps	710 (75.9)	496 (74.6)	214 (79.3)	
Army	188 (20.1)	142 (21.4)	46 (17.0)	
Other/unknown	37 (4.0)	27 (4.1)	10 (3.7)	
Injury-specific				
Mechanism, no. (%)				<.01
Improvised explosive device	382 (40.9)	247 (37.1)	135 (50.0)	
Gunshot wound	168 (18.0)	136 (20.5)	32 (11.9)	
Blast, other/unspecified	125 (13.4)	84 (12.6)	41 (15.2)	
Mortar	73 (7.8)	57 (8.6)	16 (5.9)	
Rocket-propelled grenade	66 (7.1)	52 (7.8)	14 (5.2)	
Grenade	62 (6.6)	44 (6.6)	18 (6.7)	
Fragment/shrapnel	45 (4.8)	36 (5.4)	9 (3.3)	
Other	14 (1.5)	9 (1.4)	5 (1.9)	
Multiple injuries, no. (%)[f]	653 (69.8)	500 (75.2)	150 (56.7)	<.001[d]
ISS > 8, no. (%)	174 (18.6)	142 (21.4)	15 (11.9)	<.001[d]
Outcome				
Operative procedures, no. (%)[g]	297 (31.8)	270 (40.6)	27 (10.0)	<.001[d]
Complications, no. (%)	173 (18.5)	131 (19.7)	42 (15.6)	.16[d]
Disposition, no. (%)				<.001
Deceased	37 (4.0)	21 (3.2)	16 (5.9)	
Evacuated	402 (43.0)	338 (50.8)	64 (23.7)	
Admitted[h]	91 (9.7)	58 (8.7)	33 (12.2)	
Returned to duty	399 (42.7)	243 (36.5)	156 (57.8)	
Unknown[e]	6 (0.6)	5 (0.7)	1 (0.4)	

Abbreviations: ISS, Injury Severity Score; WO, Warrant Officer.
[a] P values are for the χ^2-test unless otherwise indicated.
[b] Values are missing for 12 extremity injury and 4 other injury patients.
[c] Independent samples t-test.
[d] Fisher's exact test.
[e] Excluded from the χ^2-test.
[f] Refers to the presence of two or more concomitant injuries overall.
[g] Refers to operative procedures performed at level II medical treatment facilities.
[h] Refers to patients admitted for observation to a level II medical treatment facility.

MTFs ($P < .001$), and a higher but not statistically significant proportion of patients with extremity injury suffered complications (19.7% vs. 15.6%, P = .16).

A higher percentage of all combatants suffered upper versus lower extremity injury (47.3% vs. 43.2%). Amongst the extremity patients only (n = 665), 181 (27.2%) suffered both UEI and LEI, 261 (39.3%) patients had UEI, and the remaining 223 (33.5%) sustained LEI. In order to examine differences between these groups of extremity casualties, two separate analyses were performed (Table 4). The first analysis compared patients with "UEI and LEI" and patients with either "UEI or LEI." Patients with concomitant upper and lower extremity wounds were more often injured by IEDs than were the "UEI or LEI" group (50.8% vs. 32.0%), and they sustained higher proportions of head/neck (50.3% vs. 33.1%), abdominal (13.8% vs. 5.6%), pelvis/urogenital (19.3% vs. 5.6%), and back/buttock injury (7.7% vs. 3.1%), each with statistical significance of $P < .05$. In addition, higher proportions of "UEI and LEI" than "UEI or LEI" patients were severely injured ($P < .001$), underwent operative procedures (58.0% vs. 34.1%, $P < .001$), and had complications (30.4% vs. 15.7%, $P < .001$). Patient dispositions were also statistically different between groups ($P < .001$); "UEI and LEI" patients were more likely to be evacuated or deceased than were the "UEI or LEI" patients (69.3% vs. 44.5% and 5.0% vs. 2.5%, respectively).

Upper extremity injury casualties were then compared with the LEI patients; these groups were mutually exclusive. UEI patients were more often injured by IEDs than were the LEI group (36.4% vs. 26.9%, P = .03). A slightly higher proportion of UEI patients sustained multiple injuries (69.7% vs. 61.4%, P = .07). LEI patients, however, were more seriously injured overall ($P < .01$). The UEI patients had a higher prevalence of head/neck injury (40.6% vs. 24.2%, $P < .001$) and chest injury (10.3% vs. 4.0%, $P < .01$), whereas the LEI patients had a higher prevalence of pelvis/urogenital injury (9.4% vs. 2.3%, $P < .01$). The LEI patients were also more likely than UEI patients to undergo surgical procedures (39.0% vs. 29.9%, P = .04) and suffer complications (19.3% vs. 12.6%, P = .06). Patient dispositions between the groups, however, were not statistically different (P = .53).

Discussion

During the 6-month OIF study period, more than 70% of combat casualties included in the Navy-Marine Corps CTR sustained one or more injuries to the extremities. The majority were due to blasts, such as IEDs. Although the prevalence of extremity injury is comparable to previous studies of OIF[11,15,16,22] and other major US military conflicts,[10,12,13,18,19] a new pattern of extremity injuries has emerged during OIF. During World War II, the Korean War, and

Table 4
Comparison of injury-specific and Outcome Characteristics amongst upper extremity injury and lower extremity injury patients ($n = 665$).

Characteristics	Patients, no. (%)		P value[a]	Patients, no. (%)		P value[a]
	UEI and LEI (n = 181)	UEI or LEI (n = 484)		UEI (n = 261)	LEI (n = 223)	
Injury-specific						
Mechanism			<.001[c]			.03[c]
Improvised explosive device	92 (50.8)	155 (32.0)		95 (36.4)	60 (26.9)	
Gunshot wound	24 (13.3)	112 (23.1)		63 (24.1)	49 (22.0)	
Other/unspecified	65 (35.9)	217 (44.8)		103 (39.5)	114 (51.1)	
Multiple injuries[b]	181 (100)	319 (65.9)	NA	182 (69.7)	137 (61.4)	.07
ISS > 8	61 (33.7)	81 (16.7)	<.001	32 (12.3)	49 (22.0)	<.01
Head/neck injury	91 (50.3)	160 (33.1)	<.001	106 (40.6)	52 (24.2)	<.001
Spine injury	5 (2.8)	14 (2.9)	.93	9 (3.4)	5 (2.2)	.59
Chest injury	20 (11.0)	36 (7.4)	.16	27 (10.3)	9 (4.0)	<.01
Abdominal injury	25 (13.8)	27 (5.6)	<.01	11 (4.2)	16 (7.2)	.17
Pelvis/urogenital injury	35 (19.3)	27 (5.6)	<.001	6 (2.3)	21 (9.4)	<.01
Back/buttock injury	14 (7.7)	15 (3.1)	.02	10 (3.8)	5 (2.2)	.43
Outcome						
Operative procedures[d]	105 (58.0)	165 (34.1)	<.001	78 (29.9)	87 (39.0)	.04
Complications	55 (30.4)	76 (15.7)	<.001	33 (12.6)	43 (19.3)	.06
Disposition[e]			<.001[c]			.53[c]
Deceased	9 (5.0)	12 (2.5)		6 (2.3)	6 (2.7)	
Evacuated	124 (69.3)	214 (44.5)		108 (41.7)	106 (47.7)	
Admitted[f]	15 (8.4)	43 (8.9)		23 (8.9)	20 (9.0)	
Returned to duty	31 (17.3)	212 (44.1)		122 (47.1)	90 (40.5)	

Abbreviations: ISS, Injury Severity Score; LEI, lower extremity injury; NA, not analysed; UEI, upper extremity injury.
[a] P values are for the Fisher's exact test unless otherwise indicated.
[b] Refers to the presence of two or more concomitant injuries overall.
[c] χ^2-test.
[d] Refers to operative procedures performed at level II medical treatment facilities.
[e] Patients with unknown dispositions are not shown and were excluded from the χ^2-test.
[f] Refers to patients admitted for observation to a level I or II medical treatment facility.

Vietnam War, US combatants were more likely to sustain lower than upper extremity injury.[10,18,19] In the present study, however, a higher proportion of upper extremity casualties were identified. This finding is consistent with recent analyses of OIF.[9,16,17,22]

The widespread use of IEDs during OIF may be one cause of this new trend. IEDs are known to cause more upper than lower extremity injuries,[22] perhaps because the upper body is more vulnerable to IED blasts than to other blast mechanisms, such as landmines, that were seen more frequently in previous wars.[18,19] IEDs also have a wider range of delivery methods (e.g., suicide bombers, vehicle attachments). Exposure to an IED may also be more common amongst combatants with certain military occupational specialties. In one study of injured combatants from a mechanised battalion during OIF, 65% of injuries were due to IEDs, and the rate of UEIs were nearly twice that of LEIs. This pattern was expected, since many of these patients were marines on convoys in light armoured vehicles whose lower extremities were largely protected by the vehicle.[9] The majority of patients in our analysis were marines, but data related to their physical locations during the injury event were not available.

Although more patients in the present study suffered upper rather than lower extremity injury, LEIs were more severe overall. It is important to note that AIS severity scores indicate the degree to which any one injury is life-threatening or fatal. In some cases, injuries to the upper and lower extremity are similar with respect to the type of injury (e.g., severed artery), but the lower extremity equivalent may be more life-threatening because of the greater risk of significant blood loss, compartment syndrome, and, for long bone fractures, an increased risk of developing a blood clot.

Multiple injuries per patient were common and expected, given the effects of explosive munitions.[4] Upper body injuries (e.g., head and chest) were more often diagnosed amongst UEI patients, whereas LEI patients had a higher prevalence of lower body injuries (e.g., abdomen and pelvis). To our knowledge, these findings are unique and support the purported relationship between injury mechanism and anatomic injury location.[13] The findings for patients with both upper and lower extremity injury, of which half were injured by IEDs, were not surprising; these patients suffered higher proportions of injuries to all other anatomic locations, and thus, were more severely injured overall than patients with either UEI or LEI.

Demographically, patients with extremity injury were not different from those with other injuries, but there were intriguing distinctions with respect to injury-specific characteristics and outcomes. A higher percentage of extremity patients were injured by gunshot and were more severely injured overall in comparison with other injury patients (e.g., those with injuries to the head and/or torso). The widespread use and efficacy of modern body armour technology in preventing penetrating wounds to the head and chest during this conflict is well-recognised.[21] Although recent additions to body armour include protection for the upper and lower extremities, these devices leave some extremity areas exposed and are worn less frequently than Kevlar armored vests, helmets, and eye protection (data not shown).

Though this analysis provides important information for the ongoing assessment of the prevalence, types, and severity of extremity injuries and may aid future military medical planning, it also presents a few limitations. Studies of major US military conflicts of the twentieth century estimated the prevalence of extremity injury by assessing the site of primary injury.[18,19] The present study defined the prevalence of extremity injury as any individual with one or more injuries to the extremities (including minor injuries), which may have overestimated the impact of extremity injury during OIF than in previous conflicts. With respect to the study population, data were collected from level I and II Navy-Marine Corps MTFs only (casualties treated at forward-deployed Army facilities and casualties transported directly to Combat Support Hospitals from the point of injury were not represented), which may not accurately reflect the entire population of OIF combat casualties. Further, in many cases,

casualties who died in combat were not transported to medical treatment facilities and therefore, their injuries and impact on injury severities were not captured in the database. Although each branch of the US armed forces was represented in this examination, the majority of casualties were marines. Because of differences in force operations, occupational specialties, and body armour requirements, these data may not generalise to all branches of the military.

Another potential weakness of this study is the absence of long-term outcome data. The psychosocial and physical health outcomes of extremity injury are not well defined for injured combatants returning from Iraq and Afghanistan. A recent report of the mental health sequelae of traumatic brain injury amongst casualties from OIF identified higher proportions of mental health outcomes amongst patients with injuries to anatomic locations other than the head, of which 90% of these casualties had extremity injury. The authors suggested that extremity injury, as opposed to traumatic brain injury, may result in more immediate and visible disability.[14] Research on outcomes associated with combat extremity injury is needed and ongoing.

Despite the limitations, the present study has several strengths. To our knowledge, it is the first study to identify characteristics statistically associated with extremity injury compared with other anatomic injury and to elucidate differences between upper and lower extremity injuries. It is also unique in that we analysed objective measures of extremity injury severity (e.g., AIS), which have not been documented in previous reports of combatants injured during US military conflicts.

Conclusions

Although extremity wounds are less likely to be fatal than head, chest, or abdominal wounds,[10,18,19] these injuries can be severely disabling. The high prevalence and severity of extremity injuries from the current conflict in Iraq stresses the significance of proper and immediate orthopaedic care for combatants in theatre. Protection for the extremities has been developed and is currently in use, but improvements may help mitigate these injuries. Further research on the risks and outcomes associated with battlefield extremity injury is needed as the nature of military engagement continues to evolve.

Conflict of interest statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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